DISCUSSION OF THE AMENDMENT

Various multiply dependent claims have been amended to depend on a single claim. Claim 56 has been amended to claim an optical device or element comprising the recited CVD single crystal diamond material according to Claim 1.

No new matter is believed to have been added by the above amendment. Claims 1-77 remain pending in the application. Claims 1-61 and 75-77 are active; Claims 62-74 stand withdrawn from consideration.

REMARKS

Due to the length of the specification herein, Applicants will cite to the paragraph number of the published patent application (PG Pub) of the present application, i.e., US 2004/0229464, when discussing the application description, rather than to page and line of the specification as filed.

The rejection of Claims 1-61 and 75-77 under 35 U.S.C. § 102(e) as anticipated by or, in the alternative, under 35 U.S.C. § 103(a) as obvious over, US 6,582,513 (Linares et al), is respectfully traversed.

Applicants have discovered that a CVD single crystal diamond material having at least one novel property can be obtained by controlling two particular conditions in the formation of the CVD single crystal diamond material. One of the conditions involves controlling the level of nitrogen in the CVD atmosphere to between approximately 300 ppb and 5 ppm of nitrogen, as described in the specification at paragraphs [0049]-[0059]. The other condition is that the growth of a layer of single crystal CVD diamond take place on a diamond surface which is substantially free of crystal defects, as described in the specification at paragraphs [0060]-[0072]. More particularly, the CVD atmosphere should contain substantially no contaminants other than intentionally added nitrogen, as described in the specification at paragraph [0073].

As described in the specification at paragraph [0057], high levels of nitrogen show deleterious absorptions and may also degrade the crystal quality of the material. Conversely, material grown under conditions with essentially no nitrogen (i.e., less than 300 ppb), has a comparatively higher level of local strain generating defects, which affect directly or indirectly many of the high performance optical properties of the diamond.

Prior art has made much of preparing a flat substrate, or with a surface of a specified roughness. The presumption has been that a flat surface provides the best surface for CVD

growth. The presence of defects in this surface which adversely affect the quality of the growth has been overlooked, in part because of the lack of a means by which to detect these defects. The present invention includes a means of characterizing these surface defects, and thereby developing a means of reducing or removing such defects. Such a process provides a surface which is not merely presumed to be substantially free of crystal defects, but is known to be substantially free of crystal defects. As described in the specification at paragraphs [0062]-[0064], such defects may be intrinsic to the substrate material itself, or result from polishing or substrate processing.

These crystal defects are important because they cause the formation of defects, particularly dislocations, in the CVD layer grown onto the substrate. A dislocation, once formed, cannot simply terminate but threads its way through the growth to the growth surface. In many cases, particularly where dislocation densities are already high, additional dislocations are generated during growth so that the density of dislocations progressively gets higher with thickness. Defects of this type are particularly deleterious to material used in optical applications, causing local variations in many of the key properties.

Linares et al discloses synthetic monocrystalline diamond compositions having one or more monocrystalline CVD diamond layers, wherein one of the layers may be doped by one or more impurities such as boron (Abstract). Linares et al discloses that they provide such synthetic monocrystalline diamonds with "an improved combination of such properties as thermal conductivity, crystal perfection, coloration, strength, velocity of sound, fracture toughness, hardness, shape and the like" by modifying and controlling the amounts and/or types of impurities, such as boron, during the CVD process (paragraph bridging columns 7 and 8). Linares et al further discloses that their diamond crystal is at least about 20 μm, and more preferably at least about 75 or even 100 μm thick, grown on a single crystal seed which can be chosen from natural diamond crystals, synthetic high pressure diamond crystals, or

synthetic CVD diamond crystals (column 16, lines 45-53). In Linares et al, the concentration of impurities, such as nitrogen, is modified and the carbon isotope ratio (^{12}C, ^{13}C) is altered away from the naturally occurring value.

Linares et al discloses further that conventional CVD techniques can be used to carry out their invention (column 9, lines 13-16) and that a nitrogen concentration in the **diamond** (emphasis added) of less than 5 ppm is considered to be substantially less than normal (column 9, line 20).

Thus, there is neither disclosure nor suggestion in Linares et al that controlled levels of nitrogen of between 300 ppb and 2 ppm in the synthesis atmosphere can lead to the improvement in properties of diamond to the extent necessary for optical applications, as shown by the present invention.

Nor, since Linares et al discloses using conventional CVD techniques, does Linares et al disclose or suggest the importance of using a single crystal diamond substrate with a substrate surface which is substantially free of crystal defects, or provide a method of characterizing or preparing such a substrate.

The preparation of the substrate for CVD diamond growth is described by Linares et al only in the examples. Linares et al describes such preparation In Example 1 as follows (column 19, line 37 to 43): "A natural type IA diamond single crystal is sliced on a diamond impregnated saw to yield a substrate of (100) orientation. The substrate is polished with diamond grit suspended in olive oil and impregnated into a cast iron plate to achieve a surface which is free of grooves, scratches a (sic) or digs. This substrate is then cleaned with hot detergent in an ultrasonic cleaner, rinsed in acetone and dried."

In other examples, the same substrate preparation method is described for type IIa natural diamond, type Ib synthetic diamond and CVD diamond substrates.

The method described in Linares et al for preparing the substrate, such as it is, is lacking in detail; for example, "free of grooves" does not include a magnification at which the grooves cannot be seen or the depth or width of a groove, or the required surface roughness. As quantifiable parameters relating to the surface of the substrate are not provided, it must be concluded that the condition of the surface of the substrate is not an essential feature of Linares et al's invention. That is, the substrate does not have much impact upon the layer that is subsequently grown in accordance with the teaching thereof.

This is in complete contrast to the current invention, in terms of which it has been established that only by following the careful substrate preparation steps disclosed in the specification can single crystal CVD diamond material suitable for a range of optical applications be produced, and only then when the nitrogen content of the synthesis environment is in the range 300 ppb to 2 ppm.

Thus, one skilled in the art would not have expected the product of Linares et al to inevitably meet the terms of the present claims, and specifically to meet the properties recited therein.

For all the above reasons, it is respectfully requested that this rejection be withdrawn.

The rejection of Claims 1-61 and 75-77 under 35 U.S.C. § 102(b) as anticipated by or, in the alternative, under 35 U.S.C. § 103(a) as obvious over, US 5,443,032 (Vichr et al), is respectfully traversed.

Contrary to the Examiner's findings, Vichr et al is not drawn to method for the production of high purity diamond; rather, it is drawn to a method for joining together diamond plates to produce a larger plate. As discussed below, the conditions used for the overgrowth of the CVD diamond layer are not "high purity" conditions.

The method of Vichr et al is summarized as:

taking a number of single crystal diamond substrate plates,

placing them adjacent to each other and aligning them to form an array,

partially masking the surface of the array,

overgrowing with CVD diamond, and,

parting the overgrowth from the underlying array of substrates.

Vichr et al discloses that the "[l]arge diamond seed wafers are generated by precise alignment of several small crystallographically oriented diamond seed wafers to form larger seed plates ..." (column 5, lines 39-40). The weakness of this method is that in order for the growth over two adjacent wafers to meet up perfectly, the two wafers need to be aligned with each other over six degrees of freedom (x, y, z, and rotationally around each of these three axes) to a precision substantially smaller than the carbon-carbon bond length in diamond (C-C bond length in diamond is 0.154 nm or 1.54×10^{-10} m). If this precision (which is far beyond the current state of the art) is not attained, then the boundary between overgrowths from adjacent substrate plates will be defective as there will not be perfect correspondence between atoms on opposite sides of the boundary, giving rise to dislocations and other extended defects, and stress.

There is no disclosure or suggestion regarding the preparation of the substrates upon which the CVD diamond layer is grown, unlike the presently-claimed invention, wherein preparation of surface of the substrate as described in the specification is an essential feature of the process, as discussed above.

Nor is there a disclosure or suggestion in Vichr et al about the importance of nitrogen in CVD diamond growth. At the date at which this patent was granted, the significance and influence of nitrogen in the synthesis of CVD diamond was just becoming apparent. (For example, see R. Locher, C. Wild, N. Herres, D. Behr, P. Koidl, 'Nitrogen stabilized {100} texture in chemical vapor deposited diamond films', Applied Physics Letters, Vol. 65 (1994), No. 1, 34-37); there was certainly no understanding at the time of filing (June 1992).

The absence of any disclosure or suggestion relating to nitrogen in the gas phase during the synthesis process is exemplified by the use in Example 1 (column 8, line 54) and Example 2 (column 10, line 1) of "Hydrogen (99.999% purity)" as the gas that makes up 99% of the total gas flow. 99.999% purity hydrogen contains 0.001% or 10 ppm of gases other than hydrogen, where most of the 10 ppm is nitrogen. Thus Vichr et al, in effect, discloses growing diamond in an environment containing nitrogen in an amount approaching 10 ppm before other sources of nitrogen (the carbon containing gas, leaks, out gassing from internal surfaces of the deposition system, etc.) are considered.

In sum, Vichr et al does not disclose or suggest the importance of using a single crystal diamond substrate with a substrate surface which is substantially free of crystal defects, or provide a method of characterizing or preparing such a substrate, or the requirement that the nitrogen content in the CVD environment be controlled to be between 300 ppb and 5 ppm. Thus, one skilled in the art would not have expected the product of Vichr et al to inevitably meet the terms of the present claims, and specifically to meet the properties recited therein.

For all the above reasons, it is respectfully requested that this rejection be withdrawn.

Applicants respectfully call the Examiner's attention to the Information Disclosure Statement (IDS) filed January 8, 2008. The Examiner is respectfully requested to initial the Form PTO 1449 submitted therewith, and include a copy thereof with the next Office communication.

All of the presently-pending claims in this application are now believed to be in immediate condition for allowance. Accordingly, the Examiner is respectfully requested to pass this application to issue.

Respectfully submitted,

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